

DOCUMENT RESUME

ED 401 869

IR 017 689

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TITLE Logged On for Learning. An "Education Week" Special Report.
INSTITUTION Editorial Projects in Education, Inc., Washington, DC.
SPONS AGENCY John D. and Catherine T. MacArthur Foundation, Chicago, IL.
PUB DATE 11 Jan 95
NOTE 48p.; The version processed by ERIC has been printed from diskette and is not the printed tabloid newspaper version, though the text is the same.
AVAILABLE FROM Education Week, 4301 Connecticut Avenue., N.W., Suite 250, Washington, DC 20008.
PUB TYPE Journal Articles (080) -- Reference Materials - Bibliographies (131) -- Reference Materials - Vocabularies/Classifications/Dictionaries (134)
JOURNAL CIT Education Week; v14 n16 Suppl Jan 11 1995
EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Case Studies; Computer Networks; Computer Software Development; *Computer Uses in Education; Educational Media; *Educational Resources; Information Sources; *Internet; Online Searching; *Public Schools; Statewide Planning; *Telecommunications; User Friendly Interface
IDENTIFIERS *Connectivity; Cyberspace; Federal Communications Commission; National Information Infrastructure; Role of Technology

ABSTRACT

This document and accompanying disk contain all of the articles from an "Education Week" special report examining the complex phenomenon commonly known as the "information highway" and how it affects the nation's schools. The articles, all by Peter West, include: (1) "Logged On for Learning," an overview of the report; (2) "Wired for the Future," about classroom connectivity; (3) "Paving the Way for the Highway," discussing the Federal Communication Commission's aim to get every classroom in the United States online; (4) "States Map Out Their Digital Futures," about a meeting of state networking representatives to discuss the National Information Infrastructure; (5) "Cybersources," a brief list of recommended informational reports; (6) "A Soft Sell," about the competition among software developers to create highly marketable educational applications; (7) "Cyberspeak," important terms and definitions for the information age; (8) "Reach Out and Touch," about the user-friendliness of touch-screens; (9) "The Search is On: Internet Research Made Simple," about an Internet searching tool called the Internet Library Information Assembly Database (ILIAD); and (10) "A Competitive Marketplace," which profiles some leading telecommunications firms. (BEW)

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LOGGED ON FOR LEARNING

An *Education Week* Special Report

v15 n16

January 11, 1996

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This disk contains all of the articles and charts from Education Week's special report "Logged On for Learning," which was published January 11, 1995. This report examines the complex phenomenon commonly known as the "information highway" and how it affects the nation's schools.

The special report was made possible by a grant from the John D. and Catherine T. MacArthur Foundation.

LOGGED ON FOR LEARNING

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Logged On for Learning

Stories by Peter West

The renowned scientist and author Arthur C. Clarke recounts in *How the World Was One*, his history of the communications revolution, a tale of technological shortsightedness that resonates today.

In the 1880's, he writes, after word reached Britain that Alexander Graham Bell had invented the telephone, a parliamentary commission asked the Post Office chief engineer whether the device would be useful to Britons.

"No sir," the engineer answered. "The Americans have need of the telephone, but we do not. We have plenty of messenger boys."

Clarke was saying that in the midst of a technological revolution, it is both comforting to cling to familiar ideas and difficult to foresee how a particular invention can set off a chain of events that can change the face of society.

And so it is with the phenomenon that has come to be known as the "information highway."

The term describes a host of technological, regulatory, economic, and sociological developments that, in combination, are likely to have unforeseeable effects on the ways people communicate, use information, and learn.

Last January, when Vice President Gore challenged the telecommunications industry to wire every school and library for access to the "National Information Infrastructure," he hoped to precipitate a sea change in education akin to the one brought about by the advent of the telephone.

Yet, almost a year later, few can define what "access to the information highway" means.

This special report is designed to provide a straightforward and nontechnical discussion of some of the key issues surrounding the development of the digital information networks so that education policymakers can more effectively plan for the information age.

Wired for the Future

By Peter West
Christiansburg, Va.

From an aged armchair in a converted 1920's-era school building, Larry Arrington tosses out words and phrases like "T-1 lines," "modems," and "I.S.D.N." with abandon as he describes the future of communications that lies just over the horizon for the Montgomery County, Va., public schools.

He spins a vision, larded with the jargon of the "information age," about the district's plan for a "virtual school system" in which the lines of demarcation between home and school, between the information-rich world outside the classroom and the information-poor environment inside, will largely disappear, thanks to the telecommunications revolution.

For a system of only 8,900 students, nestled in the Blue Ridge Mountains, the district already has made some prodigious leaps into the digital age.

Each of the district's 20 schools is equipped with high-speed modems and has access to the Internet, the global network of computer networks. A recently approved technology plan spells out in detail exactly how the district hopes to catapult from the era of the printed page to the age of the computer screen by equipping schools with broadband telephone lines.

"Eventually, what we hope to have is a seamless network of interactive-video-equipped classrooms," says Arrington, the district's technology coordinator.

The school system has not always been so forward-looking. "We are one of those systems that has not done well in preparing for the future," Arrington concedes. "Not to badmouth anybody, but our past superintendent was not a computer user. Never would be."

The district had the extraordinary good fortune, however, to be located within a few miles of what is arguably one of the most "wired" communities in the United States. A short drive west on Route 460, in the small town of Blacksburg, Bell Atlantic of Virginia, Virginia Polytechnic Institute & State University, and the municipal government are engaged in an ambitious cooperative venture to provide ordinary citizens with immediate access to the so-called information highway.

Whether they're at the public library, or in the privacy of their homes, Blacksburg residents are

just a local telephone call away from the Internet--and the global communications network it supports. And the system is commonly used for everything from electronic mail to advertising.

"This is a massive social re-engineering project," asserts Andrew M. Cohill, the director of the Blacksburg Electronic Village. "We've created the electronic front porch."

The project aims to extend that electronic community to the Montgomery County district's schools and eventually to link schools and homes.

With the advent of a new school administration, and armed with grants from the National Science Foundation and Bell Atlantic to further upgrade its infrastructure, the school district is poised to act as a test site for educational applications of advanced telecommunications.

Highway to Hype

When Vice President Gore challenged the telecommunications industry last January to wire every classroom in the nation for access to the "information superhighway," it's likely he envisioned the kind of links that are available today in Blacksburg.

Yet, despite their many advantages in the race to merge onto the information highway, officials here, with the help of experts at Virginia Tech, still are pondering how ubiquitous access to telecommunications might fundamentally change the way that schools do business.

From deciding what content is appropriate for grade school students, to figuring out how to train teachers to use the networks effectively, to retrofitting aging buildings for the electronic age, the district is grappling with questions that other school systems haven't even begun to think about.

What's clear so far is that connecting to the network is just the first step schools must take.

"There's more to it than dropping computers into the classroom," says Roger Ehrich, a professor of computer science at Virginia Tech. "The whole school system was brought up without networking technology of this type."

Since the Clinton Administration took office two years ago, a seemingly endless stream of news stories about the information superhighway, its potential benefits and hazards, has filled the newspapers and airwaves.

"We've started to call it the 'information hypeway,'" says Glenn Kessler, the director of media services for the Fairfax County, Va., public schools.

Most people, however, would still be hard-pressed to define just what the term "information highway" means. And even fewer could accurately say what the Vice President's challenge implies for the way that public schools operate.

"I think it means something different to everybody," says Cheryl Williams, the director of the technology-programs department at the National School Boards Association.

Kessler, for example, notes that in Fairfax County, an affluent Washington suburb, the information highway is structurally in place. The district operates its own cable-television system and satellite, students can download materials from any library in the state, and trials are under way with various firms to provide Internet access and "video-on-demand" to every school.

Yet, for the average school district, the information highway remains just a vague and shapeless concept.

Montgomery County officials have agreed that access to the information highway means access to the Internet. Many educators, especially those with some experience with telecommunications, would agree with that conclusion.

K-12 educators have increasingly used the Internet in recent years. In part, that's because its government subsidies make the Internet essentially free to users.

Clinton Administration officials, however, are quick to point out that the Internet is just one component of a vastly upgraded national communications network that should be available to every classroom.

Many in the telecommunications industry, meanwhile, argue that the Internet model is not at all what they have in mind when they talk about connecting homes to the information highway. Instead, they expect that subscribers will one day be able to shop or call up the latest hit film through a computer-like device atop their television sets--services they hope will generate healthy revenues. The television-set model, they believe, is perfect for the large number of people who are not "computer literate."

Other observers contend that the information-highway phenomenon is an extension of the microcomputer revolution that began roughly a decade ago. The development of universal access to telecommunications networks, they say, simply increases the power of the personal computer as a productivity tool.

The reality is that the information highway will probably combine all of these elements. But which of them, if any, will be of value to educators is far from clear.

Beyond Commercialism

Although Gore has not spelled out what educational access to the information highway would look like, Administration officials largely reject the commercial model, arguing that it has little to do with the Vice President's vision.

"If people think of it as the 500 channels of television that are going to deliver entertainment or home shopping, then, in fact, they ought to be dismayed," says Linda G. Roberts, the special adviser on education technology to U.S. Secretary of Education Richard W. Riley.

She notes that in several recent national surveys, respondents gave the highest possible rating to the idea that the information highway should carry interactive educational programs.

"This is phenomenal," she adds. "It says to me that the public as a whole has really got it right. The information superhighway has the potential to bring the best of our world to our classrooms."

No two educators, technologists, and other telecommunications experts interviewed for this special report could agree on exactly how the development of the information highway will affect education.

Gordon Ambach, the executive director of the Council of Chief State School Officers, for example, argues that it will be impossible for the nation to meet its education goals unless students have relatively widespread access to telecommunications.

The jobs of the future, he predicts, will require that all workers know how to use telecommunications and how to access information by computer.

Moreover, because advanced telecommunications allows global electronic conversations and ready access to information, it has the potential to radically reform instruction, Ambach says.

"The technologies now, I believe, are actually transforming the ways that people learn," he says. "The potential of that for reshaping pedagogical design is extraordinarily powerful. I don't know where it's going to take us--but I think we need to think very carefully about it."

Many would agree that applications being tested in Montgomery County give some idea of how telecommunications could be applied in the classroom.

Here, students are developing a multimedia magazine that is posted on the Internet's Worldwide Web; Virginia Tech graduate students are helping high school physics teachers post student papers on the "net" for peer-review by experts around the globe; projects are under way to link home and school via voice mail; and teachers are encouraging students to use the Internet as a massive research library.

Even so, notes John Yrchik, a telecommunications analyst at the National Education Association, at the national level there is as yet no guiding vision for what universal access to the information highway should imply for educators.

"We're a long way from a consensus," Yrchik says, "or even a very clear direction, about where we want to go."

High-Stakes Battle

Part of the confusion stems from the fact that the information highway is actually an interrelated series of technological, regulatory, economic, and societal changes that were set in motion long before Gore challenged the industry to bring schools on board.

And for the most part, educators have been, at best, peripheral players in the game.

A central concept undergirding the phenomenon is "convergence," or the ability to convert voice, video, graphics, and computer data into digital signals and to transmit information over newer, and faster, high-volume transmission media.

Fiber-optic cables, for example, allow huge quantities of digital signals to be transmitted as pulses of light along hair-thin glass wires at high speeds over great distances. Both the telephone and cable-television industries propose to upgrade their networks with such "broadband" capability.

But the cost of replacing existing copper telephone wires with fiber-optic cables is estimated to be in the billions of dollars, causing the phone industry to argue that it must be allowed to carry such services as video-on-demand to support the costs of upgrading the network.

Yet, those same digital signals can also be transmitted by a new generation of satellites to remote or mountainous locations where laying cables would cost too much.

How the signals are carried, however, is not as important as the rich variety of information that the networks can make available to anyone, almost anywhere.

"People confuse the delivery system with the content," notes Cohill of the Blacksburg Electronic Village. "It's much more important to be connected at low speed than to say we're going to wait for a 'broadband connection.'"

The race to build the information highway is also a high-stakes regulatory battle, played out in deadly earnest in the halls of Congress, over who should be allowed to transmit what kinds of information and in what markets.

In the rapidly changing telecommunications field, some of the major players obviously include the cable-television and telephone industries. But many utility companies also have begun to weigh the idea of using fiber-optic cables that they already use for internal communications to send programming to homes and to offer such services as automated monitoring of heating and cooling systems.

In the unlikely event that all federal communications regulations were to be abolished tomorrow, the cable-television industry would likely offer customers telephone service over its lines, and the local telephone company would offer video-on-demand and home-shopping services in addition to telephone service.

But the Communications Act of 1934, the primary federal telecommunications measure that remains largely unchanged since the heyday of radio, sharply delineates the markets open to the cable industry, the Bell regional operating companies, and other players.

A bill designed to revamp the law and insure access for schools was withdrawn in the last session of Congress. But House Speaker Newt Gingrich reportedly is weighing as a blueprint for reform a "Magna Carta for the Information Age," drafted by a group of well-known futurists for the Progress and Freedom Foundation, a conservative think tank in Washington.

The most recent draft of the document does not address the idea of connecting schools to developing telecommunications networks, though it does call for sweeping deregulation of the industry.

Other conservative think tanks argue that the federal government should essentially get out of the business of regulating the telecommunications market, including oversight of educational access.

"There should be no federal policy on this issue," argues Adam Thierer, a telecommunications-policy analyst with the Heritage Foundation in Washington. "Instead, states and municipalities should determine what their needs are and create an open process that allows all carriers to compete for service."

Thierer argues that requiring access for schools and other public entities could actually slow development of the information highway by placing unfair burdens on providers that would eventually limit competition.

The one role that the federal government should play, he adds, is to insure that individual networks conform to an "open data" standard so that information can be conveyed over a variety of systems. The National Research Council endorsed that concept in its report on telecommunications called "Realizing the Information Future."

And while complex questions about "cross subsidies," regulations, and "barriers to competition" may seem abstract to education policymakers, the fact is that in places like Montgomery County, school administrators are faced almost daily with competing claims of the telecommunications companies as they jockey for market share.

"We just had that discussion in our technology committee about which is the best carrier," reports Arrington. "The cable companies are a lot more aggressive than the phone companies about this."

Paying for Change

The Vice President's challenge to the industry, observers note, has helped spur several major telecommunications firms to pledge to wire schools for the information age.

"It seems to me there's enormous power just in the idea, and just that Gore said it," Yrchik of the N.E.A. contends.

Gore's remarks also alerted the telecommunications industry to a huge new market.

Unfortunately, few educators are aware of the potential impact of the regulatory and technological change swirling around them.

"We're changing communications patterns, the way people access and retrieve information," says Connie Stout, the past chair of the Consortium for School Networking, a nonprofit umbrella organization. "It is very important that we be at the table to participate in discussions."

Unless schools get guaranteed access, it is virtually certain that homes will be connected first. Parents who can afford access to the on-line educational services available will be able to purchase them for their children, thereby widening the educational gap between economic classes.

Public schools, argues John Phillip, the executive director of the Center for Educational Leadership and Technology in Malborough, Mass., can either take advantage of the opportunity to "get into the learning business" and act as a broker for educational services for students of all ages or run the risk of becoming even further removed from the technological mainstream of society.

Unfortunately, Williams of the N.S.B.A. says, such ideas do not rank high on the list of local policymakers' priorities.

"I think you've got a group of people who don't get it," she laments.

No matter how the debate in Washington over telecommunications policy turns out, many problems unique to education must be resolved if schools are to take full advantage of digital communications.

Estimates vary wildly, for example, as to what the costs of wiring every classroom will be, how it will be paid, and by whom. At the low end, Secretary Riley has estimated it will cost \$10 billion to wire every school. High-end estimates range in the hundreds of billions of dollars.

"What we really need now in education are specific and credible proposals to fund the National Information Infrastructure," says Yrchik, "and that's what we don't have."

The Administration has provided some seed grants through pilot programs at such federal agencies as the Commerce Department's National Telecommunications and Information Administration and the N.S.F., and made technology grants a part of its Goals 2000 reform legislation.

And the Vice President recently endorsed a suggestion that money raised by the auction of the public airwaves for advanced cellular communications should be used to help defray the costs of wiring schools. But, for the most part, the Administration has said it will rely on private industry and local government to underwrite the costs.

The costs for providing access to every classroom will vary widely depending on what blend of technologies and level of service is deemed necessary to support instruction.

And while some states are experimenting with taxes on video rentals and other schemes to raise money for technology upgrades, "I don't think anybody has a clue as to the magnitude of investment we're talking about," the N.S.B.A.'s Williams says.

Meanwhile, few educators are aware of the costs associated with using telecommunications once the connections have been made to individual schools. Although regulatory bodies in some states, such as Texas, offer special rates for educational use of telecommunications, in most states, schools are charged relatively high business rates. Such costs can put even the Internet out of reach.

The Last Mile

Another major stumbling block to achieving the goal of universal classroom access is bridging the so-called "last mile" between the advanced networks and the nation's relatively old stock of school buildings, many of which require major modifications to accommodate even the most basic technologies.

According to one reliable estimate, for example, fewer than 4 percent of public school classrooms have access to telephone lines, making classroom use of telecommunications virtually impossible.

"There isn't a technology base out there," stresses Kathleen Fulton, a senior analyst at the Congressional Office of Technology Assessment, which plans to release a study this spring on teacher training in technology. "It's amazing to me how people outside of education have no idea how teachers still have to line up outside the teachers' lounge to use the telephone."

Only a handful of states, meanwhile, have begun to allocate the funds needed to wire schools for telecommunications.

Florida has spent roughly \$74 million over the past three years to help retrofit schools so they can use the statewide Florida Information Resources Network. The competitive grants average \$225,000 per school. Officials predict it will take six or seven years and \$675 million to bring every school in the state into the network.

Kentucky expects to spend \$80 million just to develop the wiring and other infrastructure to connect the state's 1,370 schools to a statewide network developed under the state's landmark 1989 reform law. To cut costs, one district required the contractor to hire students to help wire its buildings.

"We run it on a shoestring," admits Lydia Wells Sledge, who oversees the network's development. "But to implement at the speed that we want to, we do have to create time and services out of nothing."

Technology an 'Option'

Yet, outlets and cables are only part of the needed infrastructure.

The N.E.A.'s Yrchik estimates that 80 percent of classroom computers are incapable of handling multimedia software or receiving high-speed data, two key telecommunications functions.

Roughly half of the computers in schools, according to recent data, are Apple II's, a machine that was first introduced in the 1980's. While still adequate for some tasks, the discontinued Apple II simply does not have the features or computing power of newer machines.

Ronald E. Anderson, the editor of "Computers in American Schools 1992: An Overview," a survey of technology inventories and usage released by the C.C.S.S.O., says that schools have made progress in upgrading their equipment. He notes that since the 1992 survey was conducted, the percentage of schools with at least one modem has grown from 40 percent to 55 percent. The number of schools with access to cable television has risen from 55 percent to 75 percent. Meanwhile, the number of computers in the nation's schools has grown from 3.5 million in 1992 to about 5 million today.

And a recent report compiled by Quality Education Data, a Colorado-based market-research firm, found that 70 percent of school districts with enrollments greater than 25,000 reported having at least one school with Internet access.

Nonetheless, Anderson says, "it's still going to be quite a while before all of the schools are hooked up to external networks."

A related hardware problem is that few schools employ the technical support staff to effectively run a technology program. "Our problem here is manpower," Arrington says. "It's much easier for schools to buy computers than to 'buy' people."

Unlike many businesses, and even some government agencies, schools generally do not recognize the need for technical-support personnel, adds Jesse Rodriguez, who heads the division of information technologies of the Tucson (Ariz.) Unified School District.

"I can't pay a competitive rate to an individual who has the skills I need," Rodriguez says. "There's no way I can pay the technician \$50,000." Instead, the district purchased the state-of-the-art telecommunications system that allows him to troubleshoot many problems from his office.

But too often, he says, districts designate a science or mathematics teacher as the resident "technology guru" leaving that individual to run the computer program. "You might as well take a man off the streets who happens to speak Spanish and make him a bilingual teacher," he says with chagrin. "I think a basic problem is that districts are not looking at what the real costs of what managing information systems are going to be."

Finally, experts note, the vast majority of teachers have never been encouraged to use technology or provided with the support to integrate it effectively into the curriculum.

"It does not take much to excite a teacher about telecommunications," notes Norman Dodel, a professor of instructional technology in the college of education at Virginia Tech in Blacksburg. "But when they leave a place like this and go to a place where the technology is just not available, it is very likely those people will put that vision on the shelf."

Although she won't discuss the findings of the upcoming o.t.a. report, Fulton says that, in general, most teachers who use telecommunications today are self-taught. Few education schools effectively incorporate technology into their programs, she says.

And teachers, notes Melissa Matusevich, the supervisor of programs for gifted students with the Montgomery County schools and an avid user of the Internet as a classroom teacher, are not given any incentives to learn.

"We are one of the few professions that sees technology use as an option," Matusevich says.

Peter West participated in a seminar last summer on the information highway as a fellow of the Knight Center for Specialized Journalism at the University of Maryland

Paving the Way for the Highway

By Peter West
Washington

Fresh from briefing reporters about an upcoming multi-billion-dollar auction of the public airwaves, Reed E. Hundt eases into a sofa in his corner office at the Federal Communications Commission to make his case for networking every classroom for the "information age."

"We're talking about auctioning spectrum so that adults can move into the 21st century and global communications," says the F.C.C.'s chairman. The problem is "we have kids in the 19th century in terms of communications tools."

A prep-school classmate and a close friend of Vice President Gore and a law-school classmate of the President and First Lady, Hundt has developed a reputation as an innovator since beginning his five-year stint as chairman of the five-member commission in 1993.

It was Hundt's idea, for example, to auction off the licenses to provide advanced telecommunications services--licenses that once were given away free of charge. The new policy is expected to generate as much as \$12.6 billion for the U.S. treasury over the next five years.

He also has made it clear, both in public statements and in behind-the-scenes meetings with industry leaders, that he hopes to leave as a legacy of his chairmanship a regulatory framework that will help fulfill the Clinton Administration's goal of connecting every classroom to the "information highway" by the end of the decade.

"There's a very important point here: I'm talking about classrooms; I'm not talking about wiring schools," he emphasizes. "I'm not talking about building a coaxial wire to a library and stopping there. I'm not talking about building a telephone line to the principal's office so that he can take phone calls."

Legislation before the last Congress would have charged the F.C.C. with setting rules to insure that schools and libraries have affordable access to telecommunications technologies. The commission would have been required, for example, to develop regulations allowing telecom firms to offer schools, libraries, and other public entities preferential rates for network services in exchange for relatively unfettered entry into new markets.

But the Senate measure that outlined the most comprehensive reform of the nation's communications laws in 60 years was withdrawn in late September by its chief sponsor, Sen. Ernest F. Hollings. The Democrat from South Carolina argued that intense lobbying by the telephone industry made it impossible to pass the bill before adjournment.

Despite the shift in power from a Democratic-majority Congress to a Republican one, it is likely that similar bills will be introduced when Congress reconvenes this month. But whether the F.C.C. will again be designated the lead agency for insuring educational access to telecommunications remains to be seen.

Prepared for Progress

Hundt, 46, may be better prepared than any past F.C.C. chairman to meet the challenge of preparing schools for the digital age.

He taught social studies at an inner-city Philadelphia middle school for two years between graduating from Yale University and attending Yale law school.

"My experience was that there was a vast wasteland of tools and equipment out there in education, and, unfortunately, today, it's still a deficient environment," he says. "Two-thirds of all Americans at work use a computer and a network. Virtually no kids do. Or, more accurately, virtually no kids do at school. That isn't right."

He also has developed a solid reputation--perhaps to his detriment in the industry--as an advocate for curbing violence in children's television programming.

And as chairman, he has forged an unusually close alliance with Education Secretary Richard W. Riley (whom he describes as a "visionary") that has helped him better understand the technological deficiencies of schools.

He argues that all the rhetoric and hyperbole about the information highway and education boil down to a simple principle:

From their individual classrooms, teachers must be able to send and receive faxes, upload and download information from communications satellites, have access to interactive television programming, communicate with parents at home over telephone lines, and join virtual communities of their colleagues on-line.

"These are the tools that every teacher ought to have, because every business in the country is going to have them," he says.

Funding the Networks

Hundt is convinced that the expertise exists to provide meaningful content for the networks that will gradually reshape teaching.

He points to the work of filmmaker George Lucas, who is funding the development of "Edutopia," a program that aims to enable students to use telecommunications and other technologies to explore the world outside their classrooms.

"George has got a great vision," Hundt says. But "there are many other people who can do what George is talking about and who will be doing what George is doing."

What currently keeps students "locked up in educational cells" and discourages innovators like Lucas, Hundt believes, is the lack of an electronic infrastructure to deliver digital signals within a school or across the continent.

"I've been told by educators that building the networks into the classroom would be the greatest technological advance since the printing press in the art of communication," he says. "There's no teacher in this country who can't use networks to be a better teacher, and there's no teacher who can deny that."

If given the authority by Congress, Hundt has suggested, the F.C.C. could use some of the money raised by the airwaves auction to contribute to wiring the schools, in cooperation with state and local governments and private industry. Last month, the Vice President endorsed that idea, but influential Republicans countered that the money should be used to reduce the deficit, as is now intended.

Once the networks are in place, Hundt adds, schools will easily be able to afford the costs of receiving information over them.

"The price of the network and the price of the transmission are related," he says. "The way to have a cheap transmission price is to have a solution to the networking problem. And it's within the scope of the F.C.C.'s job to get that right. We should be very optimistic about this."

But, he adds, educators need to become involved at the state and local levels to insure that their needs are not overlooked as companies rush to cash in on the telecommunications revolution.

"We need everybody concerned, especially the parents, to wake up and smell the coffee," he says. "To say, 'Yes, my kid is being deprived every day of the chance to participate in the communications revolution. What am I going to do about it?'"

By Peter West

States Map Out Their Digital Futures

While debate rages on Capitol Hill over how to regulate the booming telecommunications industry nationwide, a number of individual states are moving ahead on developing digital networks to serve education.

Iowa, for example, has spent roughly \$100 million to develop a state-owned fiber-optic network that links one high school in each of its 103 counties. Yet, when legislators there learned it would cost at least that much again to extend the network to additional schools, they balked, and chose instead to lease lines from private companies.

Similarly, lawmakers in North Carolina were shocked early last year to discover that millions of dollars that had been set aside to purchase the hardware for a network of pilot schools linked to a state-owned fiber-optic network had instead been spent to cover telecommunications fees.

To better coordinate their efforts, state networking representatives met this summer in Austin, Tex., to discuss the development of the National Information Infrastructure. As a result, the U. S. Education Department's Southwest Educational Development Laboratory is developing a state-by-state inventory of networking plans and financing schemes. David Foster, a researcher who is overseeing the project, finds that telephone companies are aggressively attempting to sell services to schools and to count educators as allies in upcoming regulatory battles.

Federal Action

At the federal level, meanwhile, the U.S. Education Department's National Center for Education Statistics plans this spring to release a comprehensive report on the state of precollegiate technology.

And an alliance of five influential education groups including the National School Boards Association and the Council of Chief State School Officers--last month urged the Federal Communications Commission to act on an earlier request to help schools pay for new wiring. The groups asked that the \$300 million a year that long-distance firms must pay local phone companies for access to their lines be earmarked for educational infrastructure.

"Funding proposals or credible plans to connect schools and libraries to the N.I.I. do not exist," argued Keith Geiger, the president of the National Education Association, an alliance member.

Cybersources

By Peter West

Further information on the educational applications of telecommunications policy is available from:

* *The Internet Handbook for School Users*, a primer for K-12 educators who have little or no experience in cyberspace. Cost: \$24 plus shipping. Published by the nonprofit Educational Research Service, 2000 Clarendon Blvd., Arlington, Va. 22201; (703) 243-2100.

* *"Information Highway: Issues Affecting Development,"* a report by the U.S. General Accounting Office. Cost: Single copies of the report are free; additional copies, \$2 each. Published by the G.A.O., P.O. Box 6015, Gaithersburg, Md., 20884-6015; (202) 512-6000 or fax (301) 258-4066. Request G.A.O./R.C.E.D. 94-285 when ordering.

* *Realizing the Information Future*, a report of the computer science and telecommunications board of the National Academy of Sciences' National Research Council on how to develop the National Information Infrastructure as an open network that serves all users. Discusses issues specific to precollegiate education. Cost: \$24.94 plus shipping. Published by the National Academy Press, 2101 Constitution Ave., N.W., Washington, D.C. 20055; (202) 334-3313 or (800) 624-6242.

* *"Educational Content on the Big Wires: Partnerships Between Developers and the Cable and Telephone Industries."* A white paper on the efforts of cable-television and telephone companies to network precollegiate institutions and provide educational content for the information highway. Cost: \$250. Published by the Software Publishers Association, 1730 M St., N.W., Suite 700, Washington, D.C. 20036-4510; (202) 452-1600, ext. 185.

* *What's Fair? A Report on the Proceedings of the National Conference on Educational Fair Access and the New Media.* \$14 for a single copy; discount on orders of 25 or more. Published by TECHNOS Press, a subsidiary of the Agency for Instructional Technology, Box A, Bloomington, Ind. 47402-0120.

A Soft Sell

By Peter West
Carlsbad, Calif.

John Kernan would have you believe that the quest for the "killer app"--the Holy Grail of the information age--leads here, to a small coastal town north of San Diego and the headquarters of the Lightspan Partnership.

In his vision, the cup bearer is an animated blue moose from a distant galaxy who rides into homes and classrooms on a beam of electrons controlled by the local cable-television company. The moose's mission: to help teach youngsters the value of reading.

Killer app, in the parlance of purveyors of services for the so-called information highway, is shorthand for "killer application." Borrowed from the software industry, the term refers to a product so immediately useful--and potentially lucrative--that it will create consumer demand.

Still, for all of the hyperbolic tales about the "500-channel future" and "on ramps" that will lead to untold riches of data on the information highway, it's far from clear whether such a commodity exists. Yes, the cable-television, utility, telephone, and other telecommunications industries are eager to build a high-volume, digital delivery system to individual homes. But despite such optimism, most observers are left wondering whether there's enough quality content in the consumer market to justify the expense.

Content Counts

Whether a killer app exists, or can be developed, that will support the Clinton Administration's challenge to wire every classroom in the country to what it has dubbed the "National Information Infrastructure," or N.I.I., is an even more open question.

Certainly, a small percentage of schools already are engaged in activities--from on-line research projects on the Internet to two-way distance-learning pilot projects over fiber-optic telephone lines. And one day, industry observers predict such services will be available more widely, more efficiently, and in a more sophisticated form on the advanced networks.

But in the meantime, experts note that technology generally has yet to make noticeable changes in a critical mass of classrooms.

In fact, they point out, most of the nation's classrooms aren't even equipped with basic telephone service.

Still, Kernan--who built Josten's Learning into the largest educational software company in the nation before founding the Lightspan Partnership in 1993--says that these pessimists have all "missed the big one." The killer app, he argues, is education, a commodity that already commands billions of dollars worth of public and private spending every year.

Here, and at Lightspan's production studios in Los Angeles, teams of media technicians and educators are developing what he calls "interactive, industrial-strength K-6 curriculum," packaged as entertainment. Lightspan hopes, in short, to persuade parents that their children can learn the basics (whether or not they're taught at school) by tuning in to the commercial-free adventures of "Mars Moose" and other Lightspan characters.

Whether the Lightspan venture will succeed is, at best, a gamble. Some think the odds look good. Just last month, Kernan announced that the Comsat Corporation, the Microsoft Corporation, and TCI Technology Ventures, a subsidiary of the cable-television giant Tele-Communications Inc., had agreed to invest \$35 million in the Lightspan project.

Others wonder if Lightspan's commercial aspects will doom the company to the same litigious limbo as the advertising-supported Channel One--a comparison that infuriates Kernan. In a booming and speculative marketplace where new business alliances form daily to develop products and services for networks as yet unbuilt, picking winners and losers is akin to grasping quicksilver.

But even as lawmakers begin anew to hammer out the technical and regulatory frameworks that will undergird the N.I.L., a nagging question remains. Can enough killer apps be developed so that the average teacher and student will use the new networks as regularly and easily as they might a conventional library or any other educational resource?

The problem, according to John Lent, the director of the Scholastic Network, an on-line service aimed at K-12 teachers and students, is one of priorities. While a great deal of money is being spent to build an electronic infrastructure in some states, Lent argues, few policymakers have seriously considered how those connections might enhance--or even transform--teaching.

"There are states that are already coming up against this question," he notes. "Unfortunately, there's not a lot of thought given to content issues."

"Content," adds Frank Withrow, the director of learning technologies for the Council of Chief State School Officers, "is the name of the game."

Roadblocks Along the Way

No two experts, it seems, can agree on exactly what form, or forms, the information highway will eventually take, or even when it might be completed. But almost all informed observers would agree that the technological revolutions that will one day define the National Information Infrastructure are already at hand.

Lightspan, for example, began trials of its initial curriculum offerings in selected markets in November 1994. The company expects to formally launch its service nationwide next month. Meanwhile, in the meantime, a growing number of schools have started to tap into the Internet, a global network of computer networks, for everything from electronic mail to on-line database searches.

Indeed, experts point to regulatory and economic barriers--not technological ones--as the major roadblocks to the full deployment of the information highway.

Schools find such barriers especially challenging. Few classrooms come equipped with cable television, telephones, or modems. Even fewer are wired for new technologies. Most teachers can only provide students with obsolete personal computers. And many scramble just to offer those. What's more, the majority of the nation's schools lack the funding they need to find their way to the information highway.

Reed E. Hundt, the chairman of the Federal Communications Commission, describes the components of the information highway as vastly improved versions of the communications services most businesspeople take for granted today.

But, he adds, one important change that the Administration hopes to foster is that telephone lines, voice mail, and other communications devices become as vital to schools as they have to businesses.

Still, when that will happen is largely a matter of conjecture.

Next Best Thing to Being There

Although no one killer app has yet emerged that could alone justify the multibillion-dollar estimated cost of wiring every

classroom, there is no shortage of ideas for the kinds of educational services that can--or might one day--be delivered electronically.

The difficulty for educators will be to develop the skills necessary to discriminate between educationally meaningful fare and the merely entertaining. Indeed, the distinction between technologically feasible uses of the information highway and "vaporware"--a derisive term for fanciful ideas that are unlikely to come to fruition--continues to blur almost daily.

"To me, the hardware is the easy part. The content is the hard part," notes Mike Eason, the administrator of instructional technology for the Florida Education Department. "We have a very good system in place for the evaluation of printed material. We do not have anything similar in place for electronic media."

And the electronic choices are many.

* Working the net. Many educators think the information highway is synonymous with the Internet, whose development was largely subsidized by the federal government. Part of that misperception stems from an established familiarity with the Internet. They already use the network to organize national chat sessions, send electronic mail, and conduct research.

"To a great extent, the only real, existing element of the information highway today is the Internet," argues Bob Weir, the director of product development for EduQuest, the K-12 subsidiary of the International Business Machines Corporation. "So, from our standpoint, the first place to show a value for the instruction of students is how to employ the Internet."

Not surprisingly, I.B.M. has begun to test a system that will allow teachers to access the Internet from their classrooms and effectively search for and retrieve information.

But educator concerns go beyond Internet access. Little thought has been given to how to blend the resources of the Internet into meaningful teaching, says Jesse Rodriguez, the director of information technologies for the Tucson (Ariz.) Unified School District. "How are we going to take the next step and say, 'By the way, how are we going to take the Internet and integrate it into the curriculum?'" he wonders. "To ask, 'What are the

resources available to me on the net?"

Many observers also warn against too great a focus on the global network. Internet access, they caution, is likely to be only one of the potential applications of telecommunications technology in the digital age. And the aging installed base of school computers also limits the use of the Internet's cutting-edge multimedia features, such as the Worldwide Web, a hypertext-based navigating system.

Malcom Phelps, who heads the National Aeronautics and Space Administration's Internet resource called Spacelink, takes a conservative position. Even though the number of schools with Internet access has grown rapidly in recent years, he argues, "we are a hell of a long way from having ready access to all teachers in their classrooms."

* Going the distance. Other educators look for alternate routes along the information highway. A draft report published by the Council of Chief State School Officers in cooperation with the

U.S. Commerce Department, for example, argues that distance-learning on a national scale will play an important role in the information infrastructure. "Applications of distance-learning and learning technology resources," it notes, "are necessary for meeting the national education goals."

In a similar vein, several experiments are under way in K-12 classrooms using telepresence, a field pioneered by Robert Ballard, the renowned oceanographer who discovered the wreck of the Titanic. For six years now, the Jason Foundation, which Ballard established, has allowed students to "join" underwater biological and archaeological expeditions via satellite links and fiber-optic connections from remote geographic areas to local schools and libraries.

Meanwhile, Classroom Prodigy, an educational branch of the commercial on-line service, has joined forces with the nationally known software firm mecc to launch its own on-line archaeological expedition. Dan Buettner, who will lead the expedition, argues that such "real time" experiences could make textbooks obsolete. "The information in a textbook can change in the four or five years it takes to get to the classroom," he says. "In an increasingly MTV-style world that kids live in, this sort of

real-time delivery is going to be very important. We give kids the power to direct a learning adventure."

- * Making up for the miles. Other projects set out to circumvent the physical and geographic barriers that separate teachers and students by creating "virtual communities."

Genentech, a leading biotechnology firm based in South San Francisco, for example, has launched Access Excellence, a telecommunications project that makes virtual neighbors out of 105 biology teachers from across the country. Using America Online, a commercial computer network, the teachers share lesson plans, track flu epidemics across the United States, and discuss the latest developments in their field with Genentech staff scientists.

- * Keeping it on-line. Some states, meanwhile, are experimenting with the on-line delivery of instructional resources over existing statewide networks. In Florida, as part of an initiative called School Year 2000, vast databases, such as an electronic version of the Encyclopaedia Britannica, will soon be available to any school over the Florida Information Resource Network.

"The concept is that all of those supports that are needed to carry out the task of learning should readily be available to every student on-line," notes Phil Stockton, the vice president of editorial and production at Encyclopaedia Britannica Educational Corporation in Chicago, which is a major partner in the venture. "This is a massive undertaking. Nobody's ever tried to manage anything on this scale before."

- * Connecting to cable. Computer Curriculum Corporation of Sunnyvale, Calif., a Viacom subsidiary, has turned to cable television as its delivery system.

Late last year, C.C.C. announced plans to distribute some of the 4,000 hours of multimedia software developed for its "SuccessMaker" integrated-learning system over a Viacom cable network into home computers. As part of a cooperative pilot program with the Intel Corporation, the world's largest maker of computer chips, C.C.C. will beam the software directly into computers through a special computer chip.

Communication Is a Two-Way Street

Though there is little agreement on any other aspect of the developing market for educational software, almost all observers agree that what makes the information highway unique is the potential to develop national--and even global--communities of learners.

"The key is that the network is not just a one-way delivery system," says Hundt of the F.C.C. "It's interactive."

Kernan, for example, believes that when Lightspan hits its stride, teachers will post homework assignments on the network, students will work cooperatively from distant locations, and parents will keep in touch with their children's teachers using voice mail.

Lent would certainly agree that interactivity is the key feature of the Scholastic Network. Students and teachers interview favorite authors, celebrities, and political figures; teachers exchange curriculum tips and other information in electronic "chat rooms," and students share letters with virtual pen pals.

But what no one seems to understand, Lent argues, is that managing those electronic conversations is labor-intensive, time-consuming, and costly. "Managing that kind of interactivity is the biggest wake-up call for publishers when they get into this," he says. "Every one of your users is a reporter, and an editor, and a publisher. There aren't many people out there who know how to do it. Most people aren't even beginning to think about the issue."

Advocates of the Internet's free access to information, however, argue that the interactivity that commercial companies such as Lightspan and Scholastic offer is illusory. Those users, they say, are limited to interacting with whatever content the companies choose to make available, rather than indulging their own intellectual curiosity.

"In the Internet, users have created a new medium where there's no central authority," notes Andrew Cohill, the director of the Blacksburg Electronic Village Project, a cooperative networking venture of the municipality of Blacksburg, Va., Bell Atlantic of Virginia, and the Virginia Polytechnic Institute & State University. "There is no precedent for this in human history."

But most software developers, while enticed by the prospects of electronic delivery, are leery of security issues and copyright violations, as well as technological barriers to on-line delivery of proprietary materials.

"The issue is that the information highway is not a free-for-all," argues Mark Traphagen, a lawyer for the Washington D.C.-based Software Publishers Association. "If people can replicate information easily, they think they're entitled to do so. An average, everyday teacher doesn't understand the intricacies of the copyright law."

Form Follows Function

For some time to come, the characteristics of existing transmission systems will dictate the type of content available to schools and homes. In the future, industry analysts note, technical and regulatory "convergence" may mean that cable-television companies might provide telephone service or the electric company may use its lines to deliver video programming. But for now, existing industries are largely limited to technologies and markets at hand.

Those in the cable-television industry, for example, tend to view the potential applications of the information highway through the prism of delivery over a vastly upgraded cable network, which today is primarily a medium for delivering a televised image.

For Lightspan, the cable-television medium, at least in certain markets, allows for some interactivity between users as well as two-way communications with a "headend," or control center where the curriculum is stored. (It comes as no surprise that prior to joining Josten's, Kernan was an executive with a Northern California cable concern.)

Yet, cable television does have obvious limitations. Unlike the nation's telephone system, cable TV doesn't reach into nearly as many homes and schools, making it far from the "seamless network" the Administration has envisioned. So Lightspan also bills itself as an "open solution" to the networking problem and is willing to work with telephone and other telecommunications companies, too.

"Everybody is talking about the information highway in terms of their own perspective," notes Connie Stout of the Texas Education

Network, a joint undertaking of the Texas Education Agency and the University of Texas system. "The truth is it's going to be a strange mix of 'all of the above.'"

As eager software developers await the advent of the digital delivery system, many have turned to the CD-ROM format as a "bridge technology." By delivering their wares on CD-ROM today, they hope to demonstrate, at an elementary level, the kind of interactivity possible over the electronic networks in the not-too-distant future.

Identical to the silver platters used to record music, CD-ROM's offer immense storage capacity and a rapid rate of retrieval, two key factors in creating an interactive environment. The best CD-ROM's store voice, text, charts, animated graphics, and even full-motion video on a single disc. And most are built around some form of "hypermedia," which allows users to navigate through large volumes of interrelated information by clicking on highlighted words known as "hot buttons."

Lightspan, for example, plans to make its courseware available on CD-ROM until local cable systems can upgrade their networks to transmit the company's products.

The idea of using an existing technology until the emerging ones have been fully deployed has great appeal, says Margaret Young, a spokeswoman for Club Kidsoft, a San Francisco-based company. Club Kidsoft mails to home users thousands of CD-ROM's, each complete with a sampler of exemplary educational software programs. Potential customers can not only preview the software on the disc, but they can actually buy the product using a special code to "unlock" a security code.

"We firmly believe that electronic distribution is going to be the way that people are going to purchase software," Young says. "We really feel that the CD-ROM technology is a bridge to the digital highway."

Art Bardige, the chief executive officer of Learningways, the networking division of software publisher Davidson & Associates, adds that schools can also prepare for the networking age by acquiring multimedia P.C.'s, equipped with a CD-ROM drives and modems.

The Info Highway Goes Home

Unlike in schools, millions of dollars are already being spent to upgrade the information infrastructure with top-of-the-line multimedia computers in homes across the country.

And some analysts argue that the growing influence of the home market on the development of educational software, and on "edutainment" products for the information highway, presents both an opportunity for schools and a wake-up call for education policymakers.

Drawing on his cable-industry experience, Kernan argues that policymakers can exploit leverage they don't even know they have (or at least haven't exercised as yet) to drive the development of educational software and the installation of hardware to use it.

Superintendents, he says, should channel the competition among the players in the telecommunications industry to wire every home by exacting a promise from them to first wire every classroom. Of course, one of the premier services available to homes and classrooms in his scenario would be Lightspan's Mars Moose and other edutainment programming.

"They want those homes so badly," Kernan notes. "You have to buy a computer from Apple. But the cable industry will give it to you free. And if it won't, the telephone companies will."

Computer Curriculum Corporation's recent foray into homes also highlights the home market's growing influence. That C.C.C., which previously sold exclusively to schools, is considering on-line delivery to homes highlights the industry's perception that parents, particularly middle- and upper-middle-class parents, are willing to invest heavily in electronic resources to help their children learn.

Notes Lori McBride, the vice president of new media markets for C.C.C., "Part of the purpose of the trial is to determine what services parents want and what they want in the home that is different from what the schools want."

Many observers also note that selling software products directly to the homes is a far simpler proposition than dealing with the

cumbersome purchasing systems that most local school boards use. Others see the exploding home market as a warning to schools that they can no longer afford to ignore the electronic revolution taking place around them.

"Parents are going to be furious if schools haven't changed and don't provide something as good as or better than students can get at home," argues Sandra Welch, the executive vice president of education for the Public Broadcasting Service, which is piloting its own interactive professional-development service for mathematics teachers.

No Substitute for Substance

The potential payoff for killer-app developers is envisioned as immense, in both monetary terms and its ability to reshape teaching and learning. So the race to produce content is a competitive one that is attracting players from show business to the news business.

Reuters, the international news service, for example, recently launched a joint venture with Tele-Communications Inc. to deliver a daily, multimedia news service to schools. The Anheuser-Busch Companies have begun "repurposing" curriculum materials developed around its Sea World and other amusement parks for delivery on the Worldwide Web.

Lightspan has recruited artists, writers, animators, and special-effects artists from such entertainment-industry heavyweights as Walt Disney Studios, Paramount Pictures, and 20th Century Fox.

Others in the telecommunications industry have come to their own realization: Encouraging the development of educational content will help justify the expensive technological investments needed to use them.

Late last year, for example, the Oracle Corporation, of Redwood Shores, Calif., established a \$1 million fund to reward innovative developers of K-12 multimedia educational products specifically designed for delivery over the interactive networks. Oracle's stake in the venture is obvious: The company develops the software for the television set-top boxes that will decode the digital signals transmitted on the commercial networks.

Whatever the killer app turns out to be, it's likely that it will have to strike a delicate balance between education and entertainment.

Despite having spent years at the helm of Josten's Learning, Kernan, who also serves as the chair of the Software Publishers Association, argues that most educational software is nowhere near entertaining enough to remotely qualify as a killer app in the digital age.

"Name all of the great characters in television," he asks over his turkey sandwich. "There are thousands." Then, leaning in for the kill, he prompts with his fork, "Now, name all of your favorite characters in educational software."

Even Kernan's critics, and they are many, would have to concede that the list thins rapidly once the name "Carmen Sandiego" has passed the lips. To be successful on the new networks, Kernan argues, particularly in the crucial home market, electronic learning will have to become far more entertaining.

Harrison Miller, Lightspan's director of marketing, draws an analogy to describe how Lightspan hopes to position itself in the new marketplace. It would have been difficult, Miller says, if not impossible, in the early days of cable television to predict the success and worldwide influence of an Atlanta-based 24-hour news channel called the Cable News Network. But that's exactly the type of niche that Lightspan would like to develop and exploit on the information highway for educational publishers.

Yet, Scholastic's Lent, from his vantage point in the New York office of one of the nation's largest educational publishers, firmly disagrees with Kernan's assumption that television, interactive or otherwise, will be the on-ramp of choice for educators.

"We believe as a publisher and distributor that on-line is where the future lies," he says. "We firmly believe that somebody's 'big wire' is going to be in every school and that that presents an opportunity and a big challenge."

Lent concedes that there is debate within Scholastic over who will build and control the wires connecting schools to the information infrastructure. But when it comes to developing

educational content for the information highway, he claims the medium really is the message. "I think that in our market, the education market," he argues, "there is a fairly wide perception that TV's make you dumb and computers make you smart."

Consumers in a competitive marketplace will eventually decide whether Kernan or Lent, or both, have the winning combination.

But it would be a mistake for any electronic publisher to assume that flash can substitute for substance in the education market. So warns Nancy Ozawa of the San Francisco-based Institute for the Future, a think tank that helped develop the Access Excellence project.

Often, she says, the simplest of technological breakthroughs, such as the electronic mail available on the Internet coupled with access to a fax machine, are the most valuable tools for classroom teachers.

"I think that there is a gap between what the technology providers think is the world of classroom teachers and what it is really is," Ozawa says. "I would rather have a classroom with no technology and a really good teacher," she adds, "if it meant all those resources were available but the person didn't have a clue how to use them effectively."

Cyberspeak

Bandwidth: A measure of the information-carrying capacity of a communications channel. The speed (bit rate or velocity) at which data can be transferred and presented.

Baud: Speed of transmission in bits per second (B.P.S.) in binary (two-state) telecommunications transmission.

Bell operating company (B.O.C.): One of the 22 regulated local-exchange carriers divested from the A.T.&T. Bell telephone system by the Modification of Final Judgment (see next page) in 1984. The 22 companies are organized into subsidiaries of the seven regional holding companies, which are also called regional Bell operating companies.

Binary: A numbering system having only two digits, typically 0 and 1.

Broadband: Any system able to deliver multiple channels and/or services to its users or subscribers. Generally refers to cable-television systems. Sometimes called wideband.

Broadband communications: Term characterizing both digital and analog transmission systems. Broadband communications is generally understood to indicate either a fast data-rate digital system or a wide bandwidth analog system.

Cable television system (CATV): A broadband communications system capable of delivering multiple channels of programming from a set of centralized satellite and off-air antennae, generally by coaxial cable, to a community. Many cable-television designs integrate fiber-optic and microwave links.

CD-ROM: An acronym for "compact disk-read only memory." An optical-storage device, identical to those used to record music, that holds roughly 600 times as much data--including text, graphics, sound, and video--as a standard computer floppy disk.

Coaxial cable: A type of cable used for broadband data and cable systems. Also known as "coax."

Common carrier: A telecommunications company that offers communications services to the general public via shared circuits at published tariff rates. In the United States, the Federal Communications Commission or various state public-utility commissions regulate common

carriers.

Consortium for School Networking (CoSN): A nonprofit organization of K-12 educators, hardware and software vendors, and Internet providers. CoSN has worked to inform teachers and parents about the Internet (see next page) and its potential as an instructional tool.

Database: Information or files stored in a computer for subsequent retrieval and use.

Digital: A function that operates in discrete steps as contrasted with a continuous, or analog, function. Digital computers manipulate numbers encoded in binary (on-off) forms, while analog computers sum continuously varying forms. Digital communications is the transmission of information using discontinuous, discrete electrical or electromagnetic signals that change in frequency, polarity, or amplitude. Analog forms may be encoded for transmission on digital communications systems.

Direct broadcast satellite (D.B.S.): A satellite system designed with sufficient power so that inexpensive earth stations can be used to receive signals.

Download: To transfer information from a computer network to a personal computer.

Educational Resources Information Center (ERIC): A clearinghouse of information for educators, supported by the U.S. Education Department. It operates AskERIC, an Internet site with on-line resources for K-12 teachers.

Electronic mail ("e-mail"): The delivery of correspondence, including graphics, by electronic means, usually by interconnecting computers, word processors, or facsimile equipment.

Fax: Facsimile; a system for the transmission of images. A black-and-white reproduction of a document or picture transmitted over a telephone or other transmission system.

Federal Communications Commission: A board of five members (commissioners) appointed by the President and confirmed by the U.S. Senate under the provision of the Communications Act of 1934. The F.C.C. has the power to regulate interstate communications.

Fiber-optic cable: A cable containing one or more optical fibers.

Fiber optics: The technology of guiding and projecting light for use as a communications medium. Hair-thin glass fibers that allow light beams to be bent and reflected with low levels of loss and interference are known as "glass optical wave guides" or simply "optical fibers."

Geostationary satellite: A communications satellite, with a circular orbit 22,400 miles in space. The satellite is stationary when viewed from the Earth.

Hardware: The electrical and mechanical equipment used in telecommunications and computer systems. Contrasted with software, the programs and files that run in the equipment.

Headend: The control center of a cable-television system, where incoming signals are amplified, converted, processed, and combined into a common cable for transmission to subscribers.

Hypermedia: A nonlinear way of presenting information that allows users to access related works or images from a single computer screen. For example, a user reading an encyclopedia entry on jazz could also hear excerpts from recordings, read biographies of jazz artists, and view photos of them. Apple Computer Inc.'s HyperCard is the best-known example of hypermedia. Presumably, this type of interface is similar to normal human cognitive processes. Also known as "hypertext."

Information utility: A term increasingly used to refer to services that offer a wide variety of information, communications, and computing services to subscribers; examples include the Source, CompuServe, and Dow Jones News Retrieval.

Integrated services digital network (I.S.D.N.): A public switched network (see below) providing digital connections for the concurrent transmission of voice, video, data, and images. Often seen as a technological bridge between the current telephone system and an upgraded, broadband network.

Interactive media: New telecommunications systems designed to permit two-way communications between televisions or computers in one location with software stored on a central computer. Can also allow individuals in distant locations to communicate, teach, or learn from one another.

Interactive television (ITV): Two-way communications using a television as the display. Uses include entertainment, information retrieval, education, and shopping.

Internet: A widely used public computer network, initially developed by the U.S. military, that links smaller computer networks and allows users on different electronic-mail systems to communicate with one another on a global scale.

Local access and transport area (LATA): A telephone service region incorporating local exchanges, usually smaller than a state.

Local area network (LAN): A special linkage of computers or other communications devices into their own network for use by an individual or organization, such as a schoolwide network.

Local exchange carrier (L.E.C.): A telephone company that provides service in the local (that is, "exchange") area as well as access to other carriers.

Modem: Short for "modulator-demodulator." The equipment used to link a computer to a telephone line.

Modification of Final Judgment (M.F.J.): A 1982 agreement between A.T.&T. and the U.S. Justice Department that settled an antitrust case filed in 1974. The M.F.J. caused the divestiture or breakup of the Bell system.

National Information Infrastructure (N.I.I.): A broad proposal for the federal government to establish standards and governing bodies for the transmission of digital data. Most provisions of the N.I.I. are still being debated.

National Telecommunications and Information Administration (N.T.I.A.): An office of the U.S. Commerce Department that is designated to provide "seed grants" to support experimental educational and other public-benefit uses of the N.I.I.

Network: The circuits over which computers or other devices are connected with one another, such as over a telephone network.

On-line: Being actively connected to a network or computer system; usually being able interactively to exchange data, commands, and information.

Open-network architecture: An industrywide standard that allows different telecommunications vendors to interconnect with a network.

Public switched telephone network: The formal name given to the commercial telephone business in the United States; includes all the operating companies.

Public Utility Commission: The body, usually a state entity, that sets telephone rates.

Switched video: A residential and business video service in which customers can dial up others (much like today's telephone service) and through which customers can order video-on-demand and other video-based services. Sometimes called video dial tone.

Tariff: The published rate for a service, equipment, or facility established by the communications common carrier.

Telecommuting: The use of computers and telecommunications to enable people to work at home. More broadly, the substitution of telecommunications for transportation.

Teleconference: The simultaneous visual and/or sound interconnection that allows individuals in two or more locations to see and talk to one another in a long-distance conference arrangement.

Twisted pair: The term given to the wires that connect local telephone circuits to the central telephone office.

Two-way cable: In cable television, a distribution system that has been designed to support normal "downstream" transmissions (from the cable headend to customers), as well as "upstream" transmissions (from customer locations to the headend). Two-way cable systems are not necessarily interactive cable systems.

Universal service: Traditionally defined as making affordable voice telephone service easily available. In the coming years, it could be broadened to include other telecommunications services.

Upload: To transfer information from a personal computer into a computer network, where others can use it.

Very small aperture terminal (V.S.A.T.): A special satellite dish especially valuable for networking businesses.

Wide-area network: A network of computers spread out over a large geographic area (compare with local area network). Florida, Kentucky, Pennsylvania, Texas, and Virginia have developed, or are developing, statewide computer networks dedicated to educational use.

Worldwide Web: An Internet service that lets users retrieve hypertext and graphics from various sites. Often called just "the Web," it has become one of the most popular Internet services over the past two years.

Reach Out and Touch

By Peter West
College Park, Md.

Forget all the talk about the "on ramps" and "exits" needed to ease users onto the so-called "information highway." What's really missing is a nice, uncluttered dashboard and a few easy-to-read signposts.

So says Ben Shneiderman, the head of the Human-Computer Interaction Laboratory here at the University of Maryland's Center for Automation Research. Billions of dollars may eventually be spent to cable the proverbial "last mile" between the telecommunications industry's high-capacity transmission systems and individual users in the nation's homes, schools, and libraries. But if those wires dead-end in computer keyboards, Shneiderman argues, the number of people willing to go along for the ride will be drastically limited.

"The last mile is a problem, but it's somebody else's problem," Shneiderman admits. "To me, the problem is the 'last yard,' what happens from the screen to the user's head."

Bearded and elfin, the 47-year-old Shneiderman is one of the world's leading experts in the design of computer interfaces. He's paid, in short, to think about how to make it easier and more intuitive to retrieve, store, process, and share information by computer.

Touchy-Feely Science

The most common interface in use today, for example, is the computer keyboard. It's often coupled with the "mouse," an invention dating back to the mid-1980's, the dim past for a field where innovation is the key to survival.

Shneiderman is willing to concede that the mouse is a relatively easy-to-learn and effective navigation tool. But he doesn't have much good to say about keyboards. In fact, he suggests throwing them out.

Instead, Shneiderman advocates more user-friendly touch-screens, touch-pads, and other "visually oriented pointing mechanisms" that minimize the physical barriers to interacting with a computer.

He points to a touch-screen system developed in 1992 by researchers here in conjunction with the Library of Congress as one more intimate interface. ACCESS, an on-screen menu of options, allows patrons--even inexperienced ones--to search the library's boundless stacks simply by touching the appropriate spots on a video screen.

Two years later, the ACCESS system has largely superseded the library's existing command-line interface, known as SCORPIO, which requires four to six hours of training to use effectively. Although the more powerful SCORPIO interface is still available to professional researchers visiting the library, ACCESS has become the on-site interface of choice for the general public.

Giving every student electronic ACCESS to all of the information housed in the Library of Congress has become almost a mantra for those heralding the educational benefits of building a truly ubiquitous information highway.

Vice President Gore, for example, "is wonderful as a promoter of this scenario," Shneiderman says. "But somehow, we've got to get in there and do something to make it possible."

"Right now," he adds, "if students dial up the Library of Congress, all they're going to find is a card catalogue and the old SCORPIO interface."

Intimate Interactions

Until recently, how people interacted with their computers was of interest only to a handful of researchers, software engineers, and computer manufacturers.

Granted, the phrase "user interface" has a disturbingly impersonal ring. But, Shneiderman says, an increasing number of lay people have started to realize that interfaces influence how successfully users integrate a given technology into their daily lives.

Consider, for example, the difficulty many people have programming their videocassette recorders. In fact, the elusive function has made VCR technology one of the most common examples of what can happen when an industry fails to design a user-friendly interface.

User-friendliness will be particularly important to potential classroom users, observers note, because, as a group, educators have been hesitant to embrace technology and are seldom given incentives to do so. Given the minimal time and resources school districts generally devote to training, an easy-to-use interface is vital to bringing more teachers and students onto the information highway.

Despite stepped-up efforts to make technology more ACCESSible, Shneiderman warns that the interface issue could become a major obstacle to the Clinton Administration's hopes for a universally ACCESSible "National Information Infrastructure."

Although wary of heavy-handed government intervention in developing the information highway, Shneiderman suggests that just as the Federal Highway Administration sets standards for road signs, a federal "Information Highway Administration" must map out the digital terrain. Such an agency would "act as an agent of structure and consistency" in the digital age, insuring that electronic interfaces conform to straightforward usability standards.

"The government should say to whoever builds these highways out there: 'These are the colors for the dotted lines, these are the ways that the exit ramps are marked, and this is what a stop sign looks like,'" Shneiderman argues. But so far, he says, the Administration has failed to emphasize the importance of the interface question in its thinking about how to make its National Information Infrastructure a valuable public asset.

"'Easy to use' is easy to say," Shneiderman says. "Building it requires a lot of effort."

The Search Is On: Internet Research Made Simple

By Peter West

The Internet, the global network of computer networks, resembles nothing so much as a Middle Eastern bazaar where priceless pearls of information can often be found on the same shelf as paste imitations. If only the wide-eyed shopper knew the tricks of the trade.

New and developing software tools are emerging to help inexperienced users—including teachers and students—navigate through the billions of bits of data stored in computers from Kansas City to Karachi. But even so, it's difficult for casual users of the worldwide network to sort out the information they want and bring it safely home.

Enter Mark Rorvig, the head of a team of computer scientists at the National Aeronautics and Space Administration's Johnson Space Flight Center in Houston.

"What every professional needs," Rorvig argues, "is somebody to do your grunt work for you." And he's set out to prove it.

In partnership with the Texas Education Agency, Rorvig and a team of elementary and middle school teachers have created a software program they call a "knowledge robot" to conduct "intelligent searches" of the Internet.

Although still in its earliest stages of development, the Internet Library Information Assembly Database, or ILIAD Project, is designed to produce a sorting mechanism that will traverse the Internet and seek out information that matches user-programmed requests. In education, for example, the program classifies specific search requests using the Dewey decimal system and then searches electronic repositories for information that seems to fulfill the user's needs.

Many technical challenges lie ahead for the project. But, if successful, ILIAD could greatly reduce the time spent on Internet searches, making the network a much more productive educational resource. "We feel like we have a chance to make a tremendous impact on the teaching profession," Rorvig says. "Our goal is to arrive at a system that would allow a teacher to keep roughly 80 percent of what the robot retrieves."

The ILIAD Project is a direct offshoot of the federal High Performance Computing and Communications Act, which requires agencies such as NASA to search for ways to apply their research to support K-12 education.

"We think it's possible to develop a lot of really great curriculum aids, but we're not teachers, so we can't do that," Rorvig says. "But what we can do is develop 'intelligent agents.'"

"There's another dimension to this," he adds. "Schools right now are being wired up to take advantage of telecommunications, and they're doing this on faith." If ILIAD works, then money spent to connect schools to the Internet and other advanced computer networks could produce a much bigger bang for the buck.

Rorvig's also excited about the chance to test ILIAD on the Texas Education Network, a statewide system operated jointly by the Texas Education Agency and the University of Texas system. "If we produce something usable," he says, "then it can spread across the state of Texas."

And although ILIAD's creators currently have teachers' needs in mind, they could adapt the technology to boost productivity in a host of other fields, including applications within the space program. Aerospace engineers, for example, query from one to three databases daily. ILIAD, if properly programmed, could help streamline such searches, as well as spawn a host of other valuable spin-offs.

"A lot of things that we do impact the space program in favorable ways internally," Rorvig says. "This is a chance to do something for thousands and thousands of people, and we're very anxious to succeed."

A Competitive Marketplace

Company name: The Lightspan Partnership Inc.

Location: Carlsbad, Calif.

Description: Developer of interactive television programming for children in grades K-6.

Services: Lightspan is developing interactive, curriculum-based software to teach reading and mathematics that can be delivered over cable-television and other broadband networks into homes and schools. Initial offerings will be made available on CD-ROM until telecommunications firms upgrade their networks to handle interactive media.

Availability: The service is being pilot-tested in select districts. National availability is expected to be announced next month at the annual meeting of the American Association of School Administrators.

Contact: Harrison Miller, vice president of marketing, (619) 929-5900.

Company name: National Aeronautics and Space Administration

Location: Huntsville, Ala.

Description: An on-line resource for educators from the kindergarten to postdoctoral levels.

Services: Spacelink provides lesson plans, software, teaching activities, electronic versions of NASA publications, news about NASA missions, and other resources for classroom teachers.

Availability: Educators can access Spacelink via direct-dial modem at (205) 895-0028 or through a variety of Internet links.

Contact: Spacelink administrator, NASA's Marshall Space Flight Center, (205) 544-6360; or by electronic mail at spacelink@msfc.nasa.gov.

Company name: Scholastic Network

Location: New York

Description: An on-line service for K-12 teachers of all subjects from science to social studies.

Services: Scholastic Network schedules regular on-line forums that allow students to interview children's authors, Olympic athletes, astronauts, and other notable personalities. The network also enables users to exchange electronic mail, retrieve lesson plans, and conduct collaborative projects with other teachers.

Availability: Teachers can access the Scholastic Network through America Online.

Contact: For a rate schedule, call the Scholastic Network at (800) 246-2986.

Company name: Genentech Inc.

Location: South San Francisco, Calif.

Description: An on-line service for biology teachers developed and operated by one of the nation's leading biotechnology firms.

Services: Access Excellence is designed to break down the isolation of classroom teachers by giving them an electronic forum to share lesson plans, discuss pedagogy, and engage in cooperative teaching. The service also allows teachers to discuss scientific questions with Genentech researchers.

Availability: The service has been used by a group of 105 pilot teachers for a year. Access Excellence will be available to all America Online subscribers next month.

Contact: Pam Peters, science coordinator for Access Excellence, (415) 225-2446.

Company name: Classroom Prodigy

Location: White Plains, N.Y.

Description: A education-related subsidiary of the Prodigy computer network aimed specifically at K-12 students and teachers.

Services: Among other services, Classroom Prodigy offers students "virtual field trips," including a recent "visit" with astronauts aboard the Space Shuttle Atlantis and an upcoming project called "MayaQuest," in which students will help develop the itinerary for a archaeological

expedition to ancient ruins in Central America.

Availability: Classroom Prodigy is available through dial-up modem for Windows, Macintosh, and DOS. Multimedia features of the service are available only to Windows and Macintosh users.

Contact: For more information, call (800) Prodigy, ext. 176.

Company name: Ingenious

Location: Englewood, Colo.

Description: A joint venture of Tele-Communications Inc. and Reuters NewMedia, a U.S.-based division of the international news service Reuters Holding PLC to deliver multimedia current-events programming directly to school computers over cable-television lines.

Services: The company is poised to launch "What on Earth," a multimedia news service, incorporating lesson plans that will be delivered to homes and schools across the country over the TCI cable system. Ingenious already delivers a text-based service called XChange to 18,000 U.S. schools via cable-television lines.

Availability: What on Earth will be available in some markets on Feb. 10 and is expected to be available nationwide by mid-year.

Contact: For more information, call (800) 7pcnews.

Company name: Public Broadcasting Service

Location: Alexandria, Va.

Description: A yearlong professional-development program for mathematics teachers.

Services: Mathline delivers videotaped lessons, compatible with professional standards developed by the National Council of Teachers of Mathematics, through PBS affiliates to participating teachers. Participants can discuss the lessons through electronic mail and media "chat sessions" on an on-line PBS-supported service.

Availability: The service is available on a pilot basis through local public-television stations to 500 teachers in 16 states over the 1994-95 school year. PBS expects to increase the number of teachers enrolled in the 1995-96 school year to 2,750 in 38 states.

Contact: Local public-television stations or the Mathline staff on the Internet at mathline@pbs.org.